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Committee on the Peaceful Uses of Outer Space

Space for global health

Special report of the Inter-Agency Meeting on Outer Space Activities on the use of space science and technology within the United Nations system for global health

I. Introduction

1. The General Assembly, in its resolution 69/85, on international cooperation in the peaceful uses of outer space, urged the Inter-Agency Meeting on Outer Space Activities (UN-Space), under the leadership of the Office for Outer Space Affairs of the Secretariat, to continue to examine how space science and technology and their applications could contribute to implementing the Millennium Declaration and to the post-2015 development agenda process, and encouraged entities of the United Nations system to participate, as appropriate, in UN-Space coordination efforts to that effect.

2. UN-Space serves as the focal point for inter-agency coordination and cooperation in space-related activities within the United Nations system. At its thirty-fourth session, held in New York on 13 and 14 May 2014, UN-Space recalled that its previous special reports had addressed the following themes (A/AC.105/1064, para. 17): new and emerging technologies, applications and initiatives for space-related inter-agency cooperation (see A/AC.105/843); space benefits for Africa: contribution of the United Nations system (see A/AC.105/941); use of space technology within the United Nations system to address climate change issues (see A/AC.105/991); and space for agriculture development and food security (see A/AC.105/1042).

3. At its thirty-fourth session, UN-Space agreed that the next special report should address the theme of space for global health (A/AC.105/1064, para. 18).

4. The present report was prepared by the Office for Outer Space Affairs in cooperation with the World Health Organization (WHO), the Cartographic Section of the Department of Field Support of the Secretariat and the secretariat of the United Nations Framework Convention on Climate Change.

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II. Selected areas in which United Nations entities focus on the use of space science and technology for public health

5. Each year, non-communicable and communicable diseases and maternal, neonatal and nutrition-related conditions together cause an estimated 50 million deaths worldwide. Innovative approaches to solve health problems are needed to complement traditional good practices in the health sector. Such approaches include the use of space science and technology for health promotion, health protection, surveillance, health-care delivery in remote areas using telemedicine and tele-health services. Space science and technology provide innovative research platforms for advancing medical knowledge and spin-offs for the development of health-care equipment, operational activities and procedures. Space-based data and technologies foster connectivity in health emergencies, and the integration of space-derived information in health-care systems supports the mapping of populations, the treatment of diseases, the distribution of medication, transportation systems and water supply and sanitation and facilitates the monitoring of trends in air quality and health-related environmental factors.

6. With three of the eight Millennium Development Goals focusing specifically on health, the health sector has led the development success of the era of the Millennium Development Goals and set the stage for the achievement of even more after 2015. Health is also at the core of the sustainable development goals proposed by the Open Working Group of the General Assembly on Sustainable Development Goals in its report (A/68/970 and Corr.1). In its resolution 68/309, the Assembly decided that the proposal of the Open Working Group contained in the report should be the main basis for integrating the sustainable development goals into the post-2015 development agenda. The contribution of space science and technology to health is also fully in line with the WHO leadership priorities set out in the twelfth general programme of work of WHO, covering the period 2014-2019.

7. Space science and technology provide important tools that can support public health stakeholders in planning, research, prevention, early warning, alerts and health-care delivery. Information derived from Earth observation and meteorological satellites in combination with geographic information and global navigation satellite technologies has increasingly been used to study disease epidemiology, enabling increased use of spatial analysis to identify the ecological, environmental, climatic and other factors that can have a negative effect on public health or can contribute to the spread of certain diseases. United Nations entities assist developing countries in making use of space-based solutions to fight the spread of these diseases.

8. Satellite communications are essential for tele-health and for the management of epidemics in cases involving natural or human-made disasters. Early warning and disaster preparedness rely on data collected by satellites and validated by fieldwork. Such data products, when incorporated in a geographical database, could be used to develop spatial models for predicting high-risk areas. Space stations and their Earth-bound analogues serve as platforms for health studies. Efforts are also being made to promote international cooperation in the peaceful uses of outer space for economic, social and scientific development, in particular for the benefit of developing countries. Priorities include building indigenous capability in space policy, science and technology in the area of global health.

A. Forging international cooperation in the peaceful uses of outer space for health

9. The Action Team on Public Health (action team 6) was officially created in 2001 to follow up on the implementation of recommendations of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in Vienna from 19 to 30 July 1999. The Action Team's mission was to foster the implementation of tele-health for developing countries and improve public health services by facilitating the application of space technologies for early warning of infectious diseases.

10. In pursuing its mandate, the Action Team addressed the following issues proposed by the Office for Outer Space Affairs:

(a) Facilitating the development of national policies for utilizing broadband services and data in developing countries in order to support health surveillance and data acquisition for that purpose;

(b) Applying space-based data to develop an early warning mechanism capable of predicting public health threats and alerting authorities in a timely manner;

(c) Facilitating the provision of or access to capacity-building and training in the field of tele-epidemiology.

11. The Action Team completed a three-year consultation on the topic of tele-health and tele-epidemiology in 2010. The final report of the Action Team, on the use of space applications to improve public health (A/AC.105/C.1/L.305), was presented to the Scientific and Technical Subcommittee at its forty-eighth session, in 2011. In that report, it was noted that space technology played a significant role in supporting operational needs specific to public health practice, including areas such as early warning systems for infectious diseases, health surveillance programmes and emergency preparedness and field response. Reference was made to the numerous initiatives, programmes and activities at the global, regional and national levels and to the fact that the time had come for fostering more synergy and creating new integrated platforms to promote the convergence of common interests and needs. It was noted that the international community should benefit from those initiatives and the sharing of lessons learned in existing forums.

12. The Office for Outer Space Affairs continued its support of the Action Team's follow-up initiative for an open community approach to tele-health and telemedicine by collaborating with the University of Koblenz-Landau in Germany and the National Institute of Health of El Salvador in organizing in October 2013 an international teleconference on improving public health through low-cost technology and GPS-tailored access to risk assessment and resources, connecting experts from Austria, Canada, El Salvador, Germany, India, South Africa and Sri Lanka.

13. Recognizing the effective role of space science and technology and their applications for tele-health and tele-epidemiology, the Committee on the Peaceful Uses of Outer Space at its fifty-seventh session, in 2014, endorsed the recommendation of the Scientific and Technical Subcommittee at its fifty-first session to establish an expert group on space and global health to consider

issues related to the use of space technology for public health (A/AC.105/1065, annex I, para. 6).[1] The expert group, under the leadership of Canada, held a meeting during the fifty-second session of the Subcommittee, in 2015, and presented its method and programme of work, including a concrete timeline for its multi-year work. The expert group will, among other things, review the current and evolving state of affairs relative to the use of space technology applications in support of global health, compile practices and initiatives in that field, analyse gaps and opportunities for future development and explore possible cooperative and user-driven solutions to address those gaps (A/AC.105/1088, annex I, paras. 5-7).

B. Engaging space-based tools for public health and health-care delivery

Tele-epidemiology

14. In the area of health protection, space technology is well suited to the dynamic nature of outbreaks and epidemics of infectious diseases. Tele-epidemiology is employed by United Nations entities in cooperation with a diverse community of partners to provide information and develop models to support outbreak awareness, preparedness, response and control strategies.

15. Tele-epidemiology combines the use of information from satellite-based platforms to investigate and forecast outbreaks and the re-emergence of infectious diseases. The use of remote sensing has significantly advanced the possibility to track and visualize the real-time evolution of local outbreaks and epidemics and map the environmental influences for the epidemics and critical public health infrastructure. Space-derived information is used in tele-epidemiology in programmes for specific diseases, such as yellow fever, cholera and leptospirosis, to develop a decision-support tool and to provide information for current vaccination strategies. Applications of tele-epidemiology by United Nations entities for specific situations or diseases are discussed in the sections below.

16. The Office for Outer Space Affairs, through the United Nations Programme on Space Applications, has organized activities to improve capacities of Member States in tele-epidemiology. These include, for example, the United Nations/India/European Space Agency Regional Workshop on the Use of Space Technology in Tele-epidemiology to Benefit Asia and the Pacific, held in Lucknow, India, in October 2008.

17. Through the United Nations Programme on Space Applications, the Office for Outer Space Affairs also provided advisory assistance and financial support to the National Commission on Space Activities (CONAE) of Argentina for the organization of the Third Advanced School for Training in Landscape Epidemiology, held at the Mario Gulich Institute for Advanced Space Studies in Córdoba, Argentina, from 27 May to 7 June 2013. The training programme was organized to assist national space agencies and research and academic institutions from developing countries in the region in enhancing the use of space tools in landscape epidemiology (A/AC.105/1062, para. 40).

[1] A/69/20, para. 99.

18. WHO, as part of the International Health Regulations programme, is working with external partners to create yellow fever risk maps for the development of international travel and health guidelines, as well as supporting preparedness. Risk-mapping activity serves the purposes of minimizing the adverse effects of vaccine on travellers and preventing the spread of the disease. The maps utilize remote sensing and satellite imagery to incorporate factors such as elevation and vegetation in order to identify and demarcate areas and populations at risk (A/AC.105/961, para. 56).

19. *Protocol for Assessing National Surveillance and Response Capacities for the International Health Regulations (2005) in Accordance with Annex 1 of the IHR: A Guide for Assessment Teams*, published by WHO in December 2010, includes an item on geographic information systems (GIS). The Global Alert and Response Team manages an integrated global alert and response system for epidemics and other public health emergencies based on strong national public health systems and capacity and an effective international system for coordinated response. Using GIS in combination with space-based information as part of its response to the recent Ebola crisis is one example of how it presents surveillance information on maps using the web.[2]

20. As part of its programme for the immunization of preventable disease, the WHO Regional Office for South-East Asia has recently invested in the development of GIS-based tools and a system to promote the use of data (i.e. the collection, analysis, interpretation and review of data, including data from satellite remote sensing) in decision-making, in order to strengthen the capacity of governments and the field network of the immunization programme in the analysis and management of vaccine-preventable diseases and routine immunization data, to strengthen the surveillance of such diseases and to support the achievement of the goals of the immunization programme. The GIS-based tool, designed by the WHO Country Office in Nepal, will assist districts in planning surveillance and immunization activities.[3] The Myanmar Information Management Unit, under the direction of the Resident and Humanitarian Coordinator, contributed to the training of data assistants on the use of basic GIS techniques.

E-health

21. E-health is a generic term used to refer to all digital health-related information. Telemedicine and teleconsultations, electronic health records and hospital and health information systems, e-prescriptions and computer-assisted imaging are examples of modalities in e-health. In its resolution 58.28, the World Health Assembly stressed that e-health was "the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research".

22. WHO and the International Telecommunication Union (ITU), recognizing the importance of collaboration, have developed the National eHealth Strategy Toolkit, which encourages countries to develop national e-health strategies. The toolkit is a resource for developing or revitalizing a country's e-health strategy through the

[2] See www.who.int/csr/disease/ebola/maps/en/.

[3] See www.searo.who.int/nepal/documents/Nep_IPD_GIS/en/.

development of a national e-health vision and implementation road map, as well as a plan to monitor implementation and manage associated risks.

23. In addition, e-health issues have been the focus of a number of ITU study groups. These include ITU-D Study Group 2, Question 14 (Telecommunications for e-health); ITU-T Study Group 16, Question 28 (Multimedia framework for e-health applications); ITU-T Study Group 17, Question 9 (Telebiometrics); and the ITU-T Focus Group on Machine-to-Machine Service Layer.

Tele-health and telemedicine

24. Tele-health and telemedicine applications embrace computer and telecommunications technologies, including satellite communications, to bring medical experts into virtual contact with patients or doctors in remote and rural areas, thus avoiding costly relocation to hospitals in urban areas, which could prove detrimental to the patients' health.

25. Some recent activities organized by the Office for Outer Space Affairs in cooperation with Member States, specialized agencies and intergovernmental organizations in the area of applying space technologies to global health include the United Nations/Burkina Faso/World Health Organization/European Space Agency/Centre national d'études spatiales Workshop on the Use of Space Technology in Tele-health to Benefit Africa, held in Ouagadougou in May 2008 (see A/AC.105/915), the Workshop on Applications of Tele-health to Service Delivery in Public Health and Environment, held in Thimphu in July 2009 (A/AC.105/969, para. 25), the United Nations/Islamic Republic of Iran Regional Workshop on the Use of Space Technology for Human Health Improvement, held in Tehran in October 2011 (see A/AC.105/1021), and the International Expert Meeting on the theme "Improving public health through space technology applications: an open community approach", held in Bonn, Germany, from 30 July to 1 August 2012.

26. Several other activities or developments have taken place in the area of telemedicine, including continued collaboration between the WHO Regional Office for Europe and the European Space Agency (ESA) in the Telemedicine Alliance consortium under the auspices of the Information Society and Media Directorate-General of the European Commission; the publication of the ESA Telemedicine via Satellite Programme; and the setting up of a task force on telemedicine in sub-Saharan Africa, composed of African regional organizations, WHO, the European Commission and ESA (A/AC.105/886, para. 64).

27. The Pan-African eNetwork project is a joint initiative of the African Union and the Government of India to provide the States members of the African Union with information and communication technology services and content in the areas of telemedicine, tele-education and connectivity among the seats of government. The first phase of the project was inaugurated in 2009 in 11 countries: Benin, Burkina Faso, Gabon, Gambia, Ghana, Ethiopia, Mauritius, Nigeria, Rwanda, Senegal and Seychelles. The second phase of the project was launched in 2010. Of the 47 countries that have joined the project, 34 have received coverage; coverage in the remaining countries is to be completed towards the end of 2015.

28. The basic objective of the Pan-African eNetwork project is to assist Africa in capacity-building by imparting education to 10,000 students in Africa over a five-year period in various disciplines, using some of the best universities and

educational institutions in India. Through the project, Indian medical specialists in various areas selected by the African Union for its member States provide telemedicine services by way of online medical consultation to medical practitioners at locations in Africa.

29. Regular telemedicine and tele-education services have already been started on the Pan-African eNetwork. Telemedicine consultations are being provided from specialized hospitals in India to African countries on request. Moreover, since April 2009, 11 specialized hospitals in India have conducted 654 continued medical education sessions using the network.

C. Forecasting health risks from climate change, including extreme weather events and changes in natural environment

Climate and public health

30. According to the fifth assessment report of the Intergovernmental Panel on Climate Change, climate change is affecting health both directly, as a result of changes in temperature and precipitation and the occurrence of heatwaves, floods, droughts and fires, and indirectly, as a result of ecological disruptions brought on by climate change, such as crop failures and shifting patterns of disease vectors, or social responses to climate change, such as the displacement of populations following prolonged drought. Space-based technologies can thus contribute to the assessment of the direct effects of climate and weather on health, as well as ecosystem-mediated effects of climate change on health outcomes.

31. Space-based technologies can also be used to support operational work in the public health sector, such as mapping of the geographical distribution of meteorological events posing risks to public health and critical public health infrastructure. For example, the Vulnerability and Risk Analysis and Mapping programme of WHO uses remotely sensed and other environmental information and combines it with disaggregated vulnerability and capacity indicators to identify population and health services at risk of hazards such as floods, droughts and heatwaves and to enhance efforts to reduce disaster risk. Such technologies also have a potential to map other climate-related issues such as heatwaves and help discriminate between the effects of sudden extreme weather events and longer-term and slow-onset climate effects.

32. A workshop entitled "Enhancing Observations to Support Preparedness and Adaptation in a Changing Climate: Learning from the IPCC Fifth Assessment Report" was held in Bonn, Germany, from 10 to 12 February 2015. At the workshop, which was organized jointly by the Global Climate Observing System, the secretariat of the United Nations Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change, climate data needs were identified in key sectors, one of which was health. It was noted that the health organizations regularly used short-term weather forecasts especially for heat-health warnings as well as sand and dust warnings and advisories; however, their use of seasonal-to-decadal information was limited, seasonal data only being used by some organizations to anticipate requirements of health systems. Further development could help fill those gaps.

Meningitis

33. Meningococcal meningitis is a devastating epidemic disease in Africa, affecting the lives of individuals and communities in the "meningitis belt" of Africa, a sub-Saharan zone extending from Senegal to Ethiopia. *Neisseria meningitides*, the causal agent for the bacterial disease, is transmitted through respiratory droplets throughout the year, but the climate, notably hot, dry and dusty conditions, irritating the throat, appears to be favourable for invasive disease and associated epidemics. Furthermore, the timing of the epidemic year and the spatial distribution of disease cases throughout the "meningitis belt" strongly indicate a close linkage between the life cycle of the causative agent and climate variability.

34. Integrating the environmental knowledge in decision-support tools can assist health officials in predicting epidemics and devising vaccination strategies, and remote-sensing technology plays a key role in providing information on absolute humidity, absorbing aerosols, rainfall and land cover and other environmental influences relating to the epidemics.

35. The Meningitis Environmental Risk Information Technologies (MERIT) project, a collaborative initiative of WHO and other international organizations, research institutes and members of the environmental, public health and epidemiological communities, is aimed at facilitating the use of environmental information in public health decision-making. The project has helped to improve the understanding of the relationship between epidemics and environmental parameters, and of the requirements of the public health community, and serves as an example of amalgamating the use of Earth observations in policy formulation in the health sector.

36. A number of research projects within the MERIT framework are engaging national, regional and international institutions, including the World Meteorological Organization, national meteorological services, the African Centre for Meteorological Applications for Development, the Goddard Institute for Space Studies and the Jet Propulsion Laboratory of the National Aeronautical and Space Administration of the United States of America and the National Oceanic and Atmospheric Administration of the United States, to increase the use of relevant satellite-derived information and tools in these efforts.

D. Monitoring air quality

Air pollution

37. Air pollution has become one of the leading risks to global health. There is convincing evidence linking the risk of disease (and premature death) with exposure to fine particulate matter, even at relatively low concentrations of the pollutants. The most recent WHO and external scientific assessments have estimated that between 6 million and 7 million premature deaths could be attributed to air pollution exposure, including about 3.7 million premature deaths from ambient outdoor air pollution and another 4.3 million premature deaths from indoor air

pollution;[4] the premature deaths from indoor air pollution are largely attributable to the combustion of solid fuels in primitive stoves used by the world's poor.[5,6]

38. Exposure to particulate air pollution — and the burden of disease — can be estimated using surface monitoring stations. The urban air pollution exposure database of the WHO Global Health Observatory already includes such data on over 1,500 cities throughout the world.[7] However, many parts of the developing world, including urban and rural areas, are not included. As a result, scientists have been working to devise methods to combine surface monitoring data with data from satellite remote sensing and atmospheric transport models.

39. To advance the use of air pollution disease burden estimates, WHO has begun the development of a global platform on air quality and health, building on its existing urban air pollution database, as well as available satellite remote sensing and atmospheric transport model data from leading national and scientific institutions throughout the world. Augmenting ground-based measurements and model estimates with remote-sensing data makes it possible to increase the availability of global information on key air pollutants, especially for the most highly polluted and data-poor regions.

40. Regular updates of improved estimates, involving data from satellite remote sensing, have been provided by WHO since the beginning of 2014. Further refinements in remote-sensing methodologies, allowing for more precise retrieval of high-resolution data, can contribute to even more precise assessments of pollution sources, as well as of pollution hotspots and health impacts among particularly vulnerable populations. This creates an opportunity for better global, regional and local assessment of the burden of disease resulting from pollution, as well as the identification of key pollution sources, supporting relevant policies by providing reliable information (A/AC.105/1063, para. 38).

Mercury observations

41. Mercury is recognized as a substance producing significant adverse neurological and other health effects, with particular concerns expressed about its harmful effects on unborn children and infants. To protect human health and the environment from the adverse effects of mercury, the Minamata Convention on Mercury, a global treaty named after a city in Japan where serious health damage occurred in the middle of the twentieth century as a result of mercury pollution, was formally adopted and opened for signature in October 2013 under the leadership of the United Nations Environment Programme (UNEP).

42. Mercury, which occurs naturally, has broad uses in everyday objects and is released to the atmosphere, soil and water from a variety of sources. Controlling the

[4] There is some overlap between indoor and outdoor air pollution exposures and mortality, meaning that the total sum of mortality from all air pollution sources may be less than the sum of the mortality attributable to ambient and indoor air pollution exposures.

[5] See www.who.int/phe/health_topics/outdoorair/en/.

[6] Stephen S. Lim and others, "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010", *The Lancet*, vol. 380, No. 9859 (15 December 2012), pp. 2224-2260.

[7] See www.who.int/gho/phe/outdoor_air_pollution/exposure/en/.

anthropogenic releases of mercury throughout its life cycle has been a key factor in shaping the obligations under the Minamata Convention. In this regard, space technology has proved to be useful in providing timely and reliable information on a global scale for understanding major processes and mechanisms affecting the dynamics of mercury in the atmosphere and at interfaces with other ecosystems.

43. Remote-sensing technology makes it possible to obtain information on patterns of mercury concentration, deposition, dispersion, meteorological conditions and atmospheric transport and effectively complements ground-based observations in shaping the scientific basis for setting and implementing strategies on mercury and for evaluating current and future levels of mercury pollution.

44. UNEP (through its Global Mercury Partnership), the Economic Commission for Europe, the secretariat of the Convention on Long-range Transboundary Air Pollution and the Group on Earth Observations are the key international entities involved in fostering partnerships, providing technical assistance and capacity-building activities for the development and support of global mercury observations.

E. Controlling water quality

Water quality and availability

45. Inadequate water, sanitation and hygiene continue to pose a major threat to human health. Water quality is continuously monitored to control water characteristics, identify trends over time, identify emerging problems, determine whether pollution control programmes are working, help design pollution control efforts and respond to emergencies such as floods and spills.

46. Traditional monitoring of water quality involves on-site sampling of water and subsequent laboratorial analyses. While this provides accurate measurements, it is normally costly, time-consuming and indicative only of the situation at the particular points where the samples were obtained. Wider coverage of water quality observations can be obtained by satellite-based remote-sensing technology, which is suitable for near-real-time geographical coverage of water quality of inland freshwater systems, such as lakes, reservoirs, rivers and dams, and which is capable of detecting lake eutrophication, light penetration, phytoplankton bloom, chlorophyll levels, turbidity and other parameters.

47. The Health Mapping Project is an initiative of the WHO Collaborating Centre for Health Promoting Water Management and Risk Communication, located at the Institute for Hygiene and Public Health at the University of Bonn, Germany. It focuses on the mapping of diseases on an online geographic information system (web-GIS), in particular waterborne diseases, by integrating data from different WHO databases, including remotely sensed data. Further mapping features include access to water and waste-water infrastructure and visualization of the ratification status of the Protocol on Water and Health to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (A/AC.105/910, para. 34).

48. As another example, the Economic and Social Commission for Western Asia is coordinating the implementation of the Regional Initiative for the Assessment of the

Impact of Climate Change on Water Resources and socioeconomic vulnerability in the Arab region. This initiative generates geospatial information and analysis based on regional climate model downscaling, hydrological modelling and an integrated vulnerability assessment, which draw upon geospatial databases, satellite images, remote sensing and local observations. In particular, the regional hydrological modelling component incorporates climatic observations, elevation data, land parameters, and hydrological data on surface water and groundwater and makes it possible to enhance the understanding of potential changes in water resources in the region.

Monitoring recreational waters

49. Lakes, rivers and seas are used for a variety of recreational activities, including swimming, diving, fishing and sailing. If these activities are to be enjoyed safely, attention must be given to health hazards such as water pollution or excessive growth of toxic cyanobacteria. Space technology, through its Earth observation applications, provides vital information for assessments and monitoring programmes for bodies of water used for recreation.

50. Cyanobacteria can be found in almost every water reservoir on Earth. Aquatic cyanobacteria are known for their extensive and highly visible blooms, which can be toxic. Detection of the blooms can lead to the closure of recreational inland water systems and some coastal waters, because of contamination of the water by toxic strains of cyanobacteria and the identification of cases of human or animal poisoning. While cyanobacteria generally have fairly slow growth rates compared with many other microorganisms, they have the ability to change their concentration and position in a body of water within a very short time span.

51. Satellite-based Earth observation provides techniques that can be used for deriving near-real-time information on the state of the cyanobacterial population and toxins. Remote sensing of the optical properties of a body of water using high-resolution airborne scanners makes it possible to obtain instant information on the distribution and levels of chlorophyll and the potential presence of cyanobacterial phycobiliprotein pigments in fresh water. For vast recreational areas this technology may prove cost-effective.

52. WHO, the United Nations Educational, Scientific and Cultural Organization, UNEP and the World Meteorological Organization have cooperated closely in the development of guidelines for recreational uses of water areas. These guidelines are aimed at supporting the development of national and international policies concerning water and health and assisting countries in developing capacities to establish and maintain healthy water environments.

F. Tracking vector-borne diseases*

Biodiversity dynamics as an affecting factor for transmission of vector-borne diseases

53. Earth observation data and field data are being increasingly integrated into disease models to map and predict changes in habitats and biodiversity and calculate risks to public health. Land-use dynamics, animal reservoir mapping, the state of forest cover and water reservoirs are key determinants for the plague, Lyme disease and other vector-borne diseases. The models help environmental decision makers and public health practitioners to better understand the effectiveness of intervention measures, such as repellents, integrated pest management, land-use practices and disease treatment.

54. Lyme disease (Lyme borreliosis) is an infectious disease caused by bacteria belonging to the genus *Borrelia*, transmitted though tick bites. Ticks acquire it by feeding on infected hosts, mostly rodents. The rates of tick and human infection are generally influenced by relative populations of host mammals, which, in turn, are affected by changes in land use and the degree of forest connectivity. The Group on Earth Observations has been collaborating with others to develop a Lyme disease model and a web-based decision-support tool for risk-appropriate tick-bite protection and disease prevention.

55. Efforts are also being made to use satellite imagery to improve the surveillance and control of the plague in several countries in Central Asia where it is endemic, where the gerbil is the main animal reservoir of the disease and where movements of human populations into previously uninhabited areas are increasing the risk of human cases. In collaboration with the Centre national d'études spatiales of France and several research institutes, WHO has been involved in a pilot project in Kazakhstan to develop the use of satellite imagery for improving the monitoring of the animal reservoir, the detection of epizootic diseases, the prediction of epidemics and the development of a software tool for data management, mapping and integration of satellite images (A/AC.105/961, para. 56).

56. In 2015, the new thematic priority of monitoring and protecting biodiversity and ecosystems was included in the United Nations Programme on Space Applications. Under this thematic priority, the Office for Outer Space Affairs will organize the United Nations/Kenya Workshop on Space Technology and Applications for Wildlife Management and Protecting Biodiversity, to be held in Kenya in November 2015.

Malaria

57. Malaria is a life-threatening but preventable and curable disease caused by parasites transmitted through the bites of infected mosquitoes. The disease is widespread in tropical and subtropical regions that are present in a broad band around the equator. An estimated 3.4 billion[8] people continue to be at risk of malaria, mostly in Africa and South-East Asia. In 2012, an estimated 627,000 people

* This section includes examples of selected vector-borne diseases, and the list is not exhaustive.

[8] See www.who.int/mediacentre/news/releases/2013/world-malaria-report-20131211/en/.

died of malaria. Most deaths occur among children living in Africa, where every minute a child dies from malaria.

58. While human immunity is an important factor, transmission also depends on climatic conditions that may affect the number and survival of mosquitoes. These include rainfall patterns, temperature and humidity. Environmental factors include elevation, vegetation, land-cover type, vector density, proximity to bodies of water, kind of water (running or stagnant) and others. Remote-sensing satellites can effectively provide observations for these factors, which could be integrated into decision-support tools to predict future outbreaks of malaria and assist in devising interventions for malaria vector control in endemic countries.

59. For optimal utilization of limited resources for malaria control interventions, satellite-sensed data needs to be supported by ground-based observations. Data collected on the ground include vector species abundance, infectivity, insecticide resistance status and parasite prevalence in the population. To address broader gaps in the implementation of policies for malaria vector control, in particular technical guidance for malaria vector control programmes, the Technical Expert Group on Malaria Vector Control was established by the WHO Global Malaria Programme on the recommendation of the Malaria Policy Advisory Committee in September 2012.

60. A malaria information system was developed in one of the projects of the Institute for Hygiene and Public Health at the University of Bonn, Germany. The Institute established the Medical Geography and Public Health Workgroup, which considers medical geography as the scientific interface between the fields of geography and medicine. It applies geographical concepts, techniques and methods to medical issues and problems, focusing on the analysis of population-specific health and illness aspects. The primary areas of research include spatial-temporal analysis of the appearance of infectious diseases; water supply structures; data gathering and analysis; water safety plans; microbial water contamination; hygiene-geoecological risk analysis, health and disease mapping; geographic infection epidemiology; nature conservation and health protection; and sport and event hygiene. Satellite-based remote-sensing data play an important role in this research.

61. The malaria experiment is one of the protein crystal growth experiments conducted on the International Space Station (ISS). Protein crystallization experiments were performed on an enzyme of the malaria parasite *Plasmodium falciparum*. Due to the microgravity environment of ISS, protein molecules are aligned in an orderly manner, creating a high-quality crystal that enables the structural analysis of the protein and enhances the understanding of biological structure-function relationships. If structural analysis of the enzyme or enzyme pharmacon complex is possible, there will be a good chance of developing a pharmaceutical preparation for the effective treatment of malaria.

Rift Valley fever

62. Rift Valley fever is a viral zoonosis that primarily affects animals but also has the capacity to infect humans. Infection can cause severe disease in both animals and humans. It can also lead to considerable economic losses because of the decline in livestock. The vast majority of human infections result from direct or indirect

contact with the blood or organs of infected animals. The virus can be transmitted to humans by infected mosquitoes and blood-feeding flies.

63. Among animals, the Rift Valley fever virus is spread primarily by the bite of infected mosquitoes, mainly mosquitoes of the genus *Aedes*. The female mosquito is also capable of transmitting the virus directly to its offspring, as new generations of infected mosquitoes can hatch from eggs. This provides the virus with a sustainable mechanism for continuing its existence, as the eggs of these mosquitoes can survive for several years in dry conditions. During periods of heavy rainfall, larval habitats frequently become flooded, enabling the eggs to hatch and the mosquito population to rapidly increase, spreading the virus to the animals on which the mosquitoes feed.

64. In African countries, as well as in Saudi Arabia and Yemen, Rift Valley fever outbreaks are closely associated with periods of above average rainfall. In addition, outbreaks in East Africa are closely associated with the heavy rainfall that occurs during the warm phase of the El Niño-Southern Oscillation phenomenon, when anomalously warm sea surface temperatures cause climatic changes throughout the tropics and subtropics. In this regard, climate-based forecasting has proved to be an important means of controlling the disease. The sea surface temperature, rainfall level and response of vegetation to increased levels of rainfall can be easily measured and monitored by remote-sensing satellite imagery.

65. To enhance early warning systems for Rift Valley fever and avert impending epidemics, the Food and Agriculture Organization of the United Nations (FAO) and WHO have cooperated in the development of such forecasting models by promoting cooperation among experts, sharing feedback and experiences from past outbreaks, identifying gaps and exploring potential improvements in existing outbreak models. To further this effort, FAO and WHO invited a group of experts on modelling and forecasting outbreaks of Rift Valley fever to a two-day workshop in 2008 to share feedback from the outbreaks in the period 2006-2008, share experiences, identify gaps and explore the possibility of improving Rift Valley fever outbreak models. The objectives of the workshop were to review the history of Rift Valley fever, review the forecasting models and risk distribution maps that were available or being developed and make proposals on how those tools might be improved. The final goal was to prepare a road map, in the form of recommendations, for the development of tools for forecasting outbreaks of Rift Valley fever and for the real-time analysis of the spread of Rift Valley fever during outbreaks.

Japanese encephalitis

66. Japanese encephalitis is a viral disease that infects animals and humans, mostly in South Asia and South-East Asia. The disease is transmitted by mosquitoes belonging to the subgroups *Culex tritaeniorhynchus* and *Culex vishnui*, which breed in flooded rice fields. With the expansion of irrigated rice production systems into semi-arid areas, the flooding of the fields at the start of each cropping cycle leads to an explosive build-up of the mosquito population. This may cause the circulation of the virus to spill over from the usual hosts (birds and pigs) into the human population.

67. In a mini-project of the Japan Aerospace Exploration Agency, a risk map of Japanese encephalitis in mid- and far-western Nepal was developed based on a study of the relationship between the disease and climatic and environmental

variables. The study used satellite information on land use, digital elevation models, precipitation, vegetation and land surface temperature and examined the relationship between climatic and environmental data and medical data to estimate risk.

Early warning for other zoonotic diseases

68. A zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans. Animals thus play an essential role in maintaining zoonotic infections. Zoonoses may be bacterial, viral or parasitic, or they may involve unconventional agents. In addition to Rift Valley fever and Japanese encephalitis, which are mentioned in the preceding paragraphs, other zoonotic diseases that have recently been the subject of increased public and media attention include anthrax, bovine spongiform encephalopathy (also known as mad cow disease), Crimean-Congo haemorrhagic fever, highly pathogenic avian influenza and the Ebola virus disease.

69. Since July 2006, outbreaks of major animal diseases have been monitored worldwide by the Global Early Warning and Response System for Major Animal Diseases, including Zoonoses, a joint system that builds on the added value of combining and coordinating the alert and disease intelligence mechanisms of FAO, WHO and the World Organization for Animal Health, for the international community and stakeholders to assist in prediction, prevention and control of threats of animal disease, including zoonoses, through the sharing of information, epidemiological analysis and joint risk assessment.

70. Early warning is based on the concept that dealing with a disease epidemic in its early stages is easier and more economical than having to deal with it once it is widespread. Satellite-derived information on climatic factors is combined with economic indicators and migration statistics and is further integrated in epidemiological analysis for predicting disease threats. From a public health perspective, early warning of outbreaks with a known zoonotic potential will facilitate the development of control measures and the formulation of relevant preventive policies.

71. In addition, biologists, scientific researchers and conservation agencies employ space science and technology for tracking wildlife. Applications using global navigation satellite systems (GNSS) allow the scientific community to remotely observe relatively fine-scale movement or migratory patterns in a free-ranging wild animal, the size of an animal's home range, what other animals share an animal's range and the types of habitats an animal uses. This information can provide insights on approaches in controlling animal populations and help determine relevant interventions with regard to observed species.

72. Furthermore, outer space provides a unique opportunity for microgravity studies of various zoonotic agents. As the microgravity environment in outer space resembles human intra-intestinal conditions, both having a similar level of fluid shear, a so-called mechanical force related to the motion of fluids passing over cells, bacteria of the genus *Salmonella* were sent to ISS aboard two space shuttle missions, in 2006 and 2008, for experiments. Salmonella is a leading cause of food poisoning (salmonellosis) and related illnesses, whose symptoms include diarrhoea, fever, vomiting and abdominal cramps. The research findings, including those on a higher degree of virulence of the bacteria cultured in orbit, could provide a

foundation for the development of new therapies and vaccines to combat salmonella infections in humans.

G. Responding to global epidemics

Ebola virus disease

73. The Ebola virus disease, formerly known as Ebola haemorrhagic fever, is a severe, often fatal illness in humans. The virus is transmitted to people from wild animals and spreads in the human population through human-to-human transmission. The average case fatality rate of the disease is about 50 per cent.

74. The General Assembly, in its resolution 69/85, expressed its deep concern about the devastating effects of infectious diseases, in particular the Ebola virus disease, to the detriment of human life, society and development, urging the international community, in particular scientific and academic institutions, to undertake studies on the role of tele-epidemiology in monitoring, preparedness and response activities.

75. In August 2014, the Ebola Crisis Cell of the Department of Peacekeeping Operations and the Department of Field Support of the Secretariat was established to monitor and advise senior management on the development of the Ebola crisis. The General Assembly, in its resolution 69/1, welcomed the intention of the Secretary-General to establish the United Nations Mission for Ebola Emergency Response (UNMEER).[9] In its resolution 2177 (2014), the Security Council reiterated its appreciation for the appointments by the Secretary-General of the United Nations System Senior Coordinator for Ebola Virus Disease and the Deputy Ebola Coordinator and Emergency Crisis Manager.

76. Throughout the recent Ebola outbreak, space-based technologies provided a better understanding of the dynamics of the outbreak, the environment it was spreading in and the resources available to assist affected populations and local governments in their response. Geospatial analytical products provided by the Cartographic Section of the Department of Field Support improved the situational awareness, analysis and monitoring capabilities of the Ebola Crisis Cell by depicting the evolution of the spread of the Ebola virus.

77. From the first day of the UNMEER operations, the Cartographic Section deployed experts on geospatial information services to UNMEER headquarters and provided, jointly with UNMEER, GIS products and services to support mission situational awareness, planning, remote monitoring and surveillance, ensuring that all mission components and global Ebola response partners were equipped with suitable geospatial information to support their operations and the mission's mandate.

78. Global Ebola response partners used Global Positioning System (GPS) technology to collect valuable data on Ebola treatment centres, community care centres, laboratories, safe burial teams and Ebola patient contact tracing. Thus, this technology provided valuable input to the global Ebola response and the UNMEER database of geographical and spatial data.

[9] See A/69/389-S/2014/679.

79. Satellite imagery played an important role in monitoring the construction of Ebola treatment centres and in developing the products referred to in the previous paragraph. Emergency treatment centres had to be constructed in remote areas, with limited road access, in countries affected by the Ebola outbreak; satellite imagery provided unique and affordable opportunities to remotely monitor on a regular basis the progress of the construction of those treatment centres. Collected and processed information, integrated in analytical geospatial products provided to the emergency response management, helped to estimate the geographical coverage of treatment centres, as well as their accessibility and capacity in relation to the number of new cases in the region.

80. During the Ebola outbreak, one of the critical components of the emergency response was safe burials that would ensure that the deceased Ebola patients were buried in a safe and dignified manner and that the virus was not transmitted to the relatives, villagers and neighbours of the deceased. Safe burial teams had to travel extensively to remote locations with poor road conditions that would worsen during the rainy season. Geospatial data for remote areas were often non-existent. Satellite imagery and remote-sensing technologies provided an extremely valuable contribution to enrich geospatial databases, analyse road conditions and accessibility and provide options for travelling to the destinations.

81. In 2014, during the outbreak of the Ebola virus disease, the virus quickly spread across national borders, severely affecting Guinea, Liberia and Sierra Leone and, to a lesser extent, Mali and Senegal. Ebola-infected persons crossed borders, spreading the disease to neighbouring countries. Owing to the remote locations of the Ebola-infected persons and unofficial border crossings, geospatial data related to infrastructure along international borders were often unavailable or unreliable. Data extracted from satellite imagery made possible the enrichment of databases and provided analysis on how Ebola vectors travel across countries.

82. Geospatial visualization supported by satellite imagery has been effectively used to bring the outbreak of the Ebola virus disease to the immediate attention of international communities and the United Nations, including the Security Council and the General Assembly, to identify the rapid geographical spread of the disease and to help make an immediate, evidence-based decision to assist in the global Ebola response.

H. Employing space technology in disaster and emergency situations

83. Hazard mapping is playing an increasingly important role in early warning systems. That, coupled with the ability to map out resources, enables accurate and tailored emergency planning. In that context, the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) of the Office for Outer Space Affairs, was established to provide universal access to all types of space-based information and services relevant to disaster management to support the full disaster management cycle. UN-SPIDER serves as a gateway to space-based information for disaster management support, a bridge to connect the disaster management and space communities and a facilitator of capacity-building and institutional strengthening, in particular for developing countries.

84. GIS data sets on refugee camps and sites will better support the management of health issues, supply distribution and security and telecommunication issues. Refugees in urban areas present challenges different from those of refugees protected by the Office of the United Nations High Commissioner for Refugees (UNHCR) in camps. UNHCR has therefore extensively used satellite imagery to map the location of refugees and their access to assistance and protection in large cities such as Cairo, Damascus and Nairobi.

85. The use of satellite imagery during humanitarian crises is becoming more common. Combined with field assessment, this technology makes it possible to provide a complete picture of inflicted damage. While remote-sensing technology provides near-real-time information on areas of limited accessibility during and immediately after the conflict, field surveys supplement the assessment by detecting destruction not visible from above, such as damage to walls and other interior structures. The Operational Satellite Applications Programme of the United Nations Institute for Training and Research provides damage assessments during and after conflict situations.

I. Harnessing International Space Station benefits for health

Space benefits for health

86. Since the first human space flight in 1961, opportunities to conduct science experiments stretched beyond the Earth's surface and atmosphere. ISS, the largest, most complex and most long-standing international cooperation endeavour in outer space to date, has carried out research, technological development and testing, operational activities, medical procedures and other health-related projects.

87. Examples of research conducted on or for ISS relate to space life sciences, the health of astronauts and cosmonauts and health research. Studies have been carried out to examine the adverse effects of the microgravity environment on the human body, such as balance disorders, cardiovascular deconditioning, bone demineralization and muscle disuse atrophy; the effects of cosmic radiation and the reduction of immune responses; and the psychosocial impact of a closed, confined and multicultural environment.

88. Technology development and testing on or for space activities often produce incidental benefits or pay-offs for everyday technology in health care on Earth. The directly applicable or spin-off/spin-in/spin-through technologies led to advances in new materials, devices, procedures and organizational systems used in health care. Materials initially developed for space flights can be found in daily life in lightweight wheelchairs, scratch-resistant lenses, invisible braces or first aid thermal blankets. Magnetic resonance imaging (MRI), computed tomography and infrared ear thermometers are examples of spin-off devices.

89. Operational activities and procedures on or for space activities and ISS in areas such as logistics, software development and crew medical care led to advancements in telemedicine, macromolecular crystallization and water recycling technology. Robotic arms technology contributed not only to the development of prosthetic devices, but also to enhancements in MRI-compatible neurosurgical procedures.

90. The Office for Outer Space Affairs, under the framework of its Human Space Technology Initiative, organized a series of expert meetings to highlight potential benefits of human spaceflight for development. The series of meetings included the United Nations/Malaysia Expert Meeting on Human Space Technology, held in Putrajaya, Malaysia, in November 2011 (see A/AC.105/1017), and the United Nations Expert Meeting on the International Space Station Benefits for Humanity, held in Vienna in June 2012 (see A/AC.105/1024).

91. The Office for Outer Space Affairs also organized the United Nations Expert Meeting on the International Space Station Benefits for Health, held in Vienna in February 2014 (see A/AC.105/1069). The meeting focused on facilitating dialogue between the public health community and the space community and discussed the identification of potential synergies between the stakeholders. As follow-up, a meeting on applications of space science and technology for public health will be organized by the Office and WHO in Geneva on 15 and 16 June 2015.

J. Addressing impact of space environment

Cosmic radiation

92. Radiation is a fact of life. Naturally occurring ionizing radiation comes from a variety of sources, including sources in the Earth's crust (terrestrial radiation), sources in the human body and astronomical sources (cosmic radiation). Cosmic radiation, which comes from the Sun and other celestial objects, accounts for about half of the natural background radiation to which the world population is exposed. Because of its high energy, cosmic radiation could pose a danger to human health, but humans on Earth are shielded from most cosmic rays by the planet's magnetic field and atmosphere.

93. While interplanetary manned missions that go beyond the Earth's magnetosphere will not be protected from the space environment by the planet's magnetic shield, the crew on board ISS and its Earth-bound analogues still have the limited protection of the magnetosphere. Nevertheless, astronauts and cosmonauts are exposed to high levels of cosmic radiation, which has an adverse effect on the human body. Cosmic radiation has been shown to decrease the level of lymphocytes, thus weakening the body's immune system, and has been linked to a higher incidence of cataracts in astronauts and cosmonauts.

94. In 2014, the International Atomic Energy Agency (IAEA) published *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards — General Safety Requirements*,[10] as part of its endeavour to protect people and the environment from the harmful effects of ionizing radiation. The IAEA standards outline responsibilities of Governments in existing exposure situations, such as exposure due to natural sources, and stipulate requirements for occupational exposure of aircrew and space crew due to cosmic radiation. While the requirements of the IAEA standards with respect to dose limits do not apply to individuals in space-based activities, all reasonable efforts should be made to optimize protection

[10] *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards — General Safety Requirements*, IAEA Safety Standards Series No. GSR Part 3 (International Atomic Energy Agency, Vienna, 2014).

for individuals in space-based activities by restricting the doses received by such individuals while not unduly limiting the extent of such activities.

95. The standards are jointly sponsored by the European Commission, FAO, IAEA, the International Labour Organization, the OECD Nuclear Energy Agency of the Organization for Economic Cooperation and Development, the Pan American Health Organization, UNEP and WHO.

Space weather

96. Space weather refers to variable environmental conditions within the solar system, including global phenomena driven by large solar eruptions that impact on large areas of the Earth simultaneously. In the area of public health, it is important to understand the possible effects of solar activity and variations in the Earth's magnetic field on human health. For example, research has demonstrated that the majority of magnetic storms are followed by an increase in hospitalization of patients with cardiovascular and nervous diseases.

97. At its fifty-second session, in 2009, the Committee on the Peaceful Uses of Outer Space noted the importance of continuing to build upon the success of the International Heliophysical Year 2007, in particular by deepening the understanding of the function of the Sun and its effects on the Earth's magnetosphere, environment and climate, and noted with satisfaction the agreement reached by the Scientific and Technical Subcommittee at its forty-sixth session to consider, beginning at its forty-seventh session, a new agenda item entitled "International Space Weather Initiative" under a three-year workplan with specific focus on the effects of space weather on the Earth and its impact, inter alia, on communications and transport (A/64/20, para. 155). At its fifty-fifth session, in 2012, the Committee agreed that the Subcommittee should include on its agenda, starting from its fiftieth session, in 2013, a new regular item entitled "Space weather" (A/67/20, para. 166). At its fiftieth session, in 2013, the Subcommittee noted that, through that item, it could serve as an important advocate for efforts to close existing gaps in the space weather research field (A/AC.105/1038, para. 156). At its fifty-second session, in 2015, the Subcommittee noted with satisfaction that during its session the newly established Expert Group on Space Weather had met under the leadership of Canada and had presented its multi-year workplan, which was subsequently endorsed by the Subcommittee (A/AC.105/1088, paras. 163-169).

98. The Office for Outer Space Affairs, under the framework of its Basic Space Science Initiative, organized the United Nations/Japan Workshop on Space Weather: Science and Data Products from International Space Weather Initiative Instruments, in Fukuoka, Japan, in March 2015 with the overall objective of providing a global forum to discuss capacity-building, global observation and space weather education. In February 2015, the Office, in its capacity as the executive secretariat of the International Committee on Global Navigation Satellite Systems, organized a course on the theme "Space weather and global navigation satellite systems: the Ionosphere and Earth's magnetic field" in Rabat, focusing on building capacities in the area of space weather using existing data from GPS/GNSS stations in Africa. Those activities were aimed at promoting cooperation in the standardization, sharing and timely use of space weather data, which constitute the basis for research on health issues related to space weather.

III. Public health as a pillar in the 2018 "UNISPACE+50" theme of the Committee on the Peaceful Uses of Outer Space

99. The year 2018 marks the fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE), held in Vienna in 1968. The Legal Subcommittee at its fifty-fourth session (A/AC.105/1090, paras. 233-234) and the Scientific and Technical Subcommittee at its fifty-second session, in 2015, agreed to the main proposal made by the past, present and incoming chairs of the Committee on the Peaceful Uses of Outer Space, whereby the commemoration in 2018 would be a fitting time to take stock of the contributions of the three UNISPACE conferences to global space governance. As agreed by the Scientific and Technical Subcommittee, the preparatory work for 2018 could benefit from the work of the expert group on space and global health (A/AC.105/1088, para. 69, and annex I, paras. 3-4).

100. In this context, the present report serves as a contribution to the work of the expert group on space and global health and the preparations for the 2018 "UNISPACE+50" theme of the Committee and its subsidiary bodies. In that regard, the following areas could serve as examples for further consideration:

(a) Raising awareness of the potential contribution of space technology and applications to global health;

(b) Engaging with users, researchers, decision makers and other stakeholders in the public health sector to identify further needs in tools and data that could be provided with the means of space technology and its applications;

(c) Strengthening capacities in terms of the discovery of, access to and processing and use of space-derived data and information and furthering the development of relevant tools and information systems;

(d) Promoting institutional development by focusing on advancing the integration of space-derived data and information into the decision-making processes in public health;

(e) Supporting the harmonized use of space technology in public health through the standardization and updating of space-derived information, with a view to eliminating duplication and overlap;

(f) Promoting international cooperation for increased use of space-derived data and information for planning and decision-making processes in public health, including for the mitigation of impacts of humanitarian crises.